**Science Benchmark: 06 :05**
Microorganisms are those things that are visible as individual organisms only with the aid of magnification. Microorganisms are components of every ecosystem on Earth. Microorganisms range in complexity from single to multicellular organisms. Most microorganisms do not cause disease and many are beneficial. Microorganisms require food, water, air, ways to dispose of waste, and an environment in which they can live. Investigation of microorganisms is accomplished by observing organisms using direct observation with the aid of magnification, observation of colonies of these organisms and their waste, and observation of microorganisms' effects on an environment and other organisms.

**Standard 05:**
Students will understand that microorganisms range from simple to complex, are found almost everywhere, and are both helpful and harmful.
**Objective 1:** Observe and summarize information about microorganisms.

**<u>Activity 1:</u> Naked to theEye**

**<u>Intended Learning Outcome:</u>**
1-Use science process and thinking skills
3-Understand science concepts and principles
4-Communicate effectively using science language and reasoning

**<u>Teacher Background:</u>**
Microorganisms vary in size. Molds can be seen with only slight magnification and use of an ordinary magnifying glass. Yeasts must be viewed through a microscope that magnifies several hundred times. Bacteria can best be seen when studied with a more powerful microscope that enlarges 1,000 times.

It helps to understand something about cells when studying microorganisms. All living organisms, large and small, have one thing in common: the cell. This is a tiny living factory capable of converting simple food substances into energy, and creating new cell material, making it possible for the cell to reproduce itself. Many microorganims are unicellular or single-celled but some are multicellular. **Kingdom Monera**
Bacteria make up the largest group of microorganisms. People often think of them as germs that do harm. Actually, only a small number of bacteria types ar*e* disease-causing. There are thousands of different kinds of bacteria. Since some differ only slightly, they require a highly trained person to identify them. There are also groups that differ greatly in growth habits and appearance, and are quite easily identified.

Bacteria also vary somewhat in size, but average about 1/25,000 inch. In other words, 25,000 bacteria laid side by side would occupy only one inch of space. One cubic inch is big enough to hold *nine trillion* average-size bacteria; about 3,000 bacteria for every person on earth. Bacteria multiply by binary fission or cell division. Bacteria double every: 1/2 hour at 32°C; 1 hour at 21°C; 2 hours at 16°C; 6 hours at 4°C; 20 hours at 0°C; and 60 hours at -2°C.

Bacteria and other microorganisms need food in order to grow and multiply. They vary in their food needs, but nearly everything we consider as food can also be used as food by some types of bacteria (some bacteria can synthesize or make their own food).

**Kingdom Protista**

The kingdom Protista contains many species and a greater variety of organisms. Although most protists are unicellular (single-celled), some are multicellular organisms and may be quite large. While some protists get their food from their environments, others make their own food. Protists may live on land or in water. Because they are so diverse, the members of the kingdom Protista are difficult to classify. They are divided into three main groups: animal-like, plant-like, and fungus-like protists.

***Animal-like Protists***

The animal-like protists are single-celled or colonial organisms called ***protozoans***. They live in fresh and salt water, in the soil, and in the bodies of other organisms. All protozoans get food from their environments. Some absorb nutrients through their cell membranes, whereas others engulf larger particles of food. Most protozoan can move.

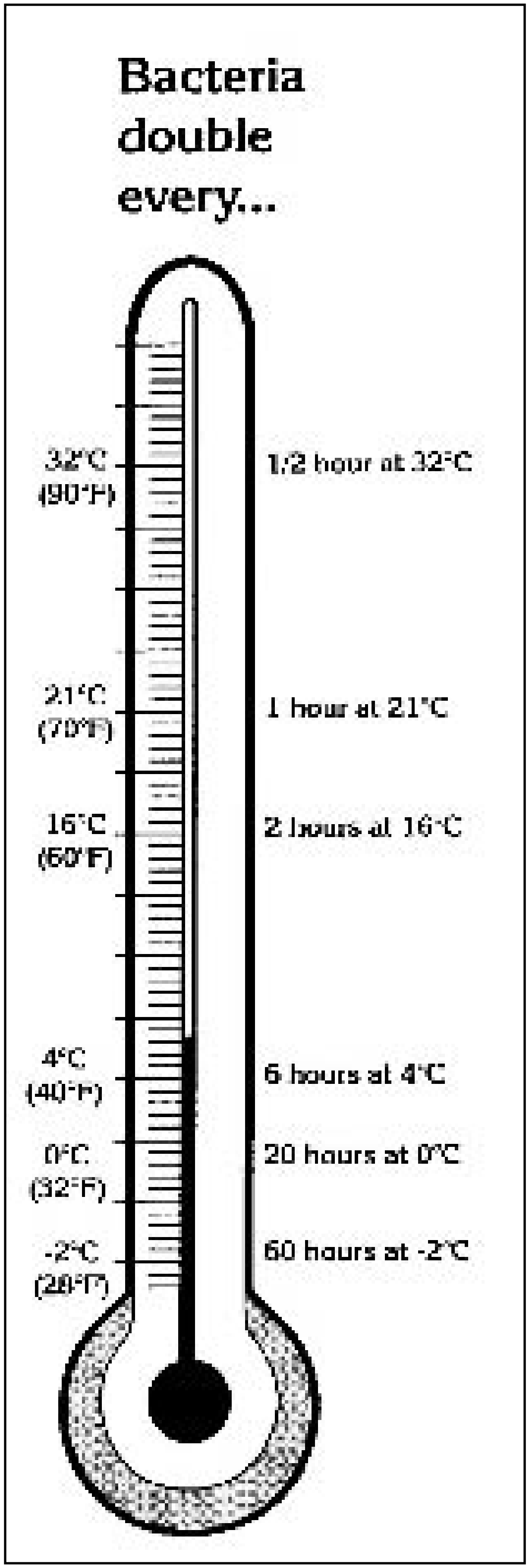
*Amebas* are single-celled organisms that continually change shape and engulf food particles. They are commonly found in freshwater ponds, lakes, and streams. *Plasmodium* is a protozoan that causes malaria, a serious, sometimes fatal, disease. The spores from this parasite invade the red blood cells of the human host, multiply there, then break out and invade new cells. The destruction of the red blood cells releases toxic cell wastes into the bloodstream. These waste products cause fever, chills, and other symptoms of malaria. Although malaria can be treated with drugs, one method of prevention is to eliminate the *Anopheles* mosquito. In spite of the widespread use of pesticides in many countries, millions of people, especially in tropical areas are still infected with malaria.

***Plant-like Protists***

The plantlike protists, commonly called algae, are photosynthetic like plants. Like the protozoa, algae are very diverse. Some are tiny, single-celled organisms with flagella. Others are large, multicellular organisms like seaweed. Like plants, algae have chloroplasts, which contain the photosynthetic pigment chlorophyll.

Another group in this category is called the *euglenoids*. These single-celled protists have both plant-like and animallike characteristics. Like plants, they contain chloroplasts. However, they do not have cell walls. Like some of the protozoa, euglenoids move by means of flagella. One typical euglenoid is *Euglena,* an organism common in pond water.

The *Euglena* is a single-celled organism having two flagella. The cell has a large, central nucleus and numerous chloroplasts which contain chlorophyll. Chlorophyll gives *Euglenas* their grass-green


Bacteria double every...
32°C (90°F)
1/2 hour at 32°C
21°C (70°F)
1 hour at 21°C
16°C (60°F)
2 hours at 16°C
4°C (40°F)
6 hours at 4°C
0°C (32°F)
20 hours at 0°C
-2°C (28°F)
60 hours at -2°C

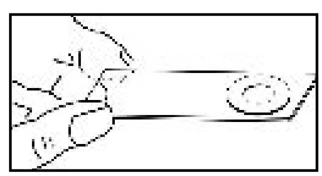
color. *Euglenas* are primarily photosynthetic. However, in the absence of light, they absorb dissolved nutrients from the environment.

## Activity A: Magnification

**Materials:**
- glass slides
- quarter-inch (USS) washers/ 3 per student
- petroleum Jelly
- toothpicks
- 15 magnifiers (Hand lenses, 1/pair of students)
- microscope (at least one)
- “Microscope” video, “Virtual Microscope” CD, or “Microorganism” CD
- “Magnification Worksheet”
- 15 pipettes

**Invitation to Learn:**
Ask students to make a dot with their pencils on a paper. Ask them how many bacteria they think could fit on the dot. Accept any answer and write it on the board. The answer is between 500-1,000 bacteria. Ask students how we know about organisms this small and discuss why magnification must be used to study the structure of most microorganisms. Scientists also gather information on microorganisms by the effect they have on other things such as illness or decay.

**Instructional Procedures:** 1. Provide each student with a Magnification “m” Worksheet, hand lens, glass slide and three washers.
2. Instruct each student to look at the letter “m” with a 3x magnifier and then draw what they see in actual size in the appropriate box on the worksheet.
3. Ask the students to apply some petroleum jelly with a toothpick to one side of a washer and place it on the glass slide (they will be able to maneuver the slide better if they apply the washer to one end of the slide). Have them add a few drops of water into the center of the washer using a pipette until the water is almost even with the top of the washer. Instruct them to use this “lens” to view the 1x letter “m” and then draw its actual size in the appropriate box on the worksheet. They should estimate how many times the letter has been magnified. Repeat this same step using two more washers. BE SURE TO ASK THEM TO PREDICT THE MAGNIFICATION OF THIS LAST LENS BEFORE THEY MAKE THAT OBSERVATION.



4. If you plan to have students use microscopes in class, discuss the proper use and handling of the microscope (see microscope manual, encyclopedia, web sites noted in the Resources section)
5. Observe some microorganisms using either videos, CD’s, or by looking at prepared slides at microscope work stations. Discuss the amount of magnification being used to view the specimens.

## Activity B: Growing Microorganisms

**Materials:**

- 4 locking plastic bags
- 4 slices of bread (homemade or bread without preservatives)
- permanent marker or pen
- water spray/mist bottle
- paper towel

**Instructional Procedures:**

1. Select four slices of bread, preferably from a loaf without preservatives (this will speed your mold growth). Give each piece the following treatment and then place the slice into a “treatment-labeled” locking plastic bag. Store the bags in warm, dark place for incubation.
2. Wipe an unwashed hand (pretend you are smearing on mayonnaise with your entire hand) on both sides of the slice, then place it into a locking plastic bag.
3. Lick one slice on both sides, with your tongue.
4. Wipe one slice, on both sides, on the floor.
5. WASH YOUR HANDS. Place the slice onto a paper towel. Moisten the slice with water from a spray/mist bottle.

Observe the bread for microorganism growth every other day for the next week. (This may take longer if you are using bread that contains growth inhibitors, preservatives.) Ask students to record their observations. At the end of 2 weeks review the results and make some class conclusions. *Most of the growths on the bread will be fungal.*

## Activity C: Pond Life

**Materials:**

- quart or pint jars
- eyedroppers, or 1ml pipettes
- slides • coverslips • Pond Life identification sheet
- microscopes (If you have a standard microscope with a low power magnification of about 100 times [written 100x] and a high power of 400x you have the most important item of equipment. If you do not have microscopes, a video or CD that allows your students to view the movement, color, appendages, and shape of pond water microbes will suffice).

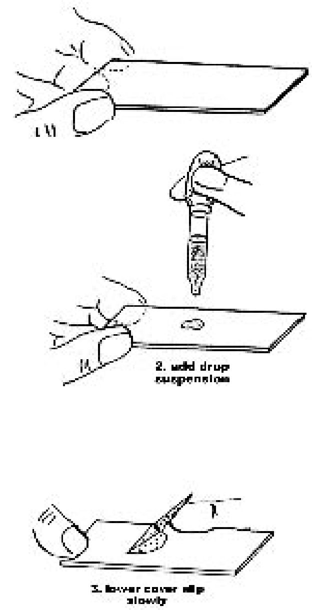
**Instructional Procedures:**

1. Collect protists from local pond water (or other source noted above) by scooping up (use the lid or your hand) the scum and algae on top of the water. Even in midwinter, protists may be scooped up in debris or vegetation on top or on the bottom of the pond.
2. Fill the jars 2/3 full with the pond water.
3. Keep the jars in a well-lit area, preferably one that is reached by moderate sunlight. You don’t want the water to get too hot or you’ll kill the creatures. Be careful about direct sunlight. Within 24-48 hours, some protists that were scattered through the jar will become concentrated at the top

where they may be found more easily and in greater numbers. Others may become concentrated near the bottom of the jar. 4. Using an eyedropper, suck-up some pond water from the top or the bottom of the jar, place a drop or two on a slide and then cover the drop with coverslip. 5. Observe the slide, if no protists are found, make more slides.

6. Ask students to draw what they observed.
7. Ask students to compare the similarities and differences of organisms they see growing on the bread and the microorganisms in the pond water. Use the Kingdom and Characteristic Charts to aid in the discussion.
8. Finally, see if they can identify what they saw using their drawing and the identification key.

The jars should be kept for several weeks. The species that are most numerous one day may be absent the next day, replaced by other species. The protozoa which feed on bacteria may be helped by steeping a small amount of grass or alfalfa hay in warm water. The proportion of hay to water should be enough to produce a color similar to strong green tea. Two tablespoons of hay infusion added to a quart jar, or one tablespoon added to a pint jar should be sufficient to revive your protozoa.




Possible Extensions/Adaptations/Integration:

***Activity A: More Observation Possibilities***

This activity is a variation on bread media observations. Wash your hands and then slice two potatoes into four pieces. Give each piece the following treatment and then place the slice into a "treatment-labeled" plastic locking bag. Store the bags in a warm dark place for incubation. 1) Dip one potato piece into a 5% solution of chlorine bleach (5ml in 100ml). Remove the piece with sterilized tweezers and place it into a plastic locking bag. 2) Put fingerprints all over another piece, or pass it around the classroom for everyone to touch (unwashed hands). 3) Ask one student to wash hands and then touch a piece on both sides. 4) Wipe one piece on both sides on the floor. 5) Using a variety (use three potato pieces for this) of "antibacterial" wipes, lotion, and/or hand sanitizer, have a student use one product on his/her hands then touch both sides of the potato. 6) Use the last potato piece as a control, no treatment.

Observe the potatoes for microbial growth every other day for the next week. Ask students to record their observations. At the end of 2 weeks review the results and make some class conclusions. *Most of the growths on the potatoes will be fungal.*

Activity B: More Observation Possibilities

Obtain sterile agar petri plates and carefully label them with name, date, experiment, and any other pertinent identification information. Do not open the lid until you are ready to inoculate (contaminate) the nutrient agar. Expose the petri dish of agar medium to microorganisms by performing one or more of the following:

a. Sprinkle some yeast on the medium.
b. Using a cotton swab, rub across mold on cheese then rub on the medium in the petri dish.
c. Using an eye dropper, deposit a drop or two of pond water/ditch water onto the medium in the petri dish.
d. Rub your finger (after washing hand thoroughly) on your face and then rub same finger on medium in petri dish (being careful not to tear the surface of the agar).

e. Place strand of hair on the medium in petri dish.
f. Place a fine layer of soil onto the agar.

Seal the petri dishes with clear tape. Place the petri dishes in a drawer (or other warm dark place) overnight and observe the next day and after 3 and 7 days. This is the incubation period. Have students write what they observed on each petri dish on a piece of paper. After incubation, observe the types of microorganisms that have grown on the surface of the plate. Many microorganisms will have formed visible colonies. A colony is a group of microbial cells resulting from the reproduction of one or more cells that were deposited on the medium surface and grew into a visible collection of cells. Discuss with students what took place in the petri dishes. Create a Venn diagram with your student to compare the microorganisms.

**Additional Resources:**
*History of the Light Microscope* www.utmem.edu/~thjones/hist/hist_mic.htm

How to use a microscope www.usoe.k12.ut.us/curr/science/sciber00/7th/cells/sciber/intro.htm

Cells
www.clarityconnect.com/webpages/cramer/pictureit/cells.htm www.purchon.com/biology/cells.htm
http://personal.tmlp.com/Jimr57/index.htm
http://gened.emc.maricopa.edu/bio/bio181/BIOBK/ BioBookCELL2.html#Table%20of%20Contents
www.nyu.edu/education/mindsinmotion/individual/bg243/

*Guide to Microlife*, Kenneth G. Rains & Russell. Published by Franklin Watts Danbury, Connecticut, 1996.

*Magnificent Microworld Adventures*, Mike Wood, Published by AIMS Edcuation Foundation, California, 1995.

Foods of Biblical Times, video shows how the ancient world made cheese, yogurt, wine, etc. Available from Utah Agriculture in the Classroom, www.agclassroom.org/ut.

Microorganism CD's, microscopes, and microbe videos are available from Carolina Biological; www.carolinabiological.com (order a catalog) and other Science Supply vendors.

*Materials adapted from materials provided by Utah State University Extension and Utah Agriculture in the Classroom, www.agclassroom.org/ut*

Great microscope links for students:
www.geocities.com/EnchantedForest/Dell/5400/resources.html#life
www.cellsalive.com
www.utmem.edu/personal/thjones/hist/hist_mic.htm
www.pfizerfunzone.com

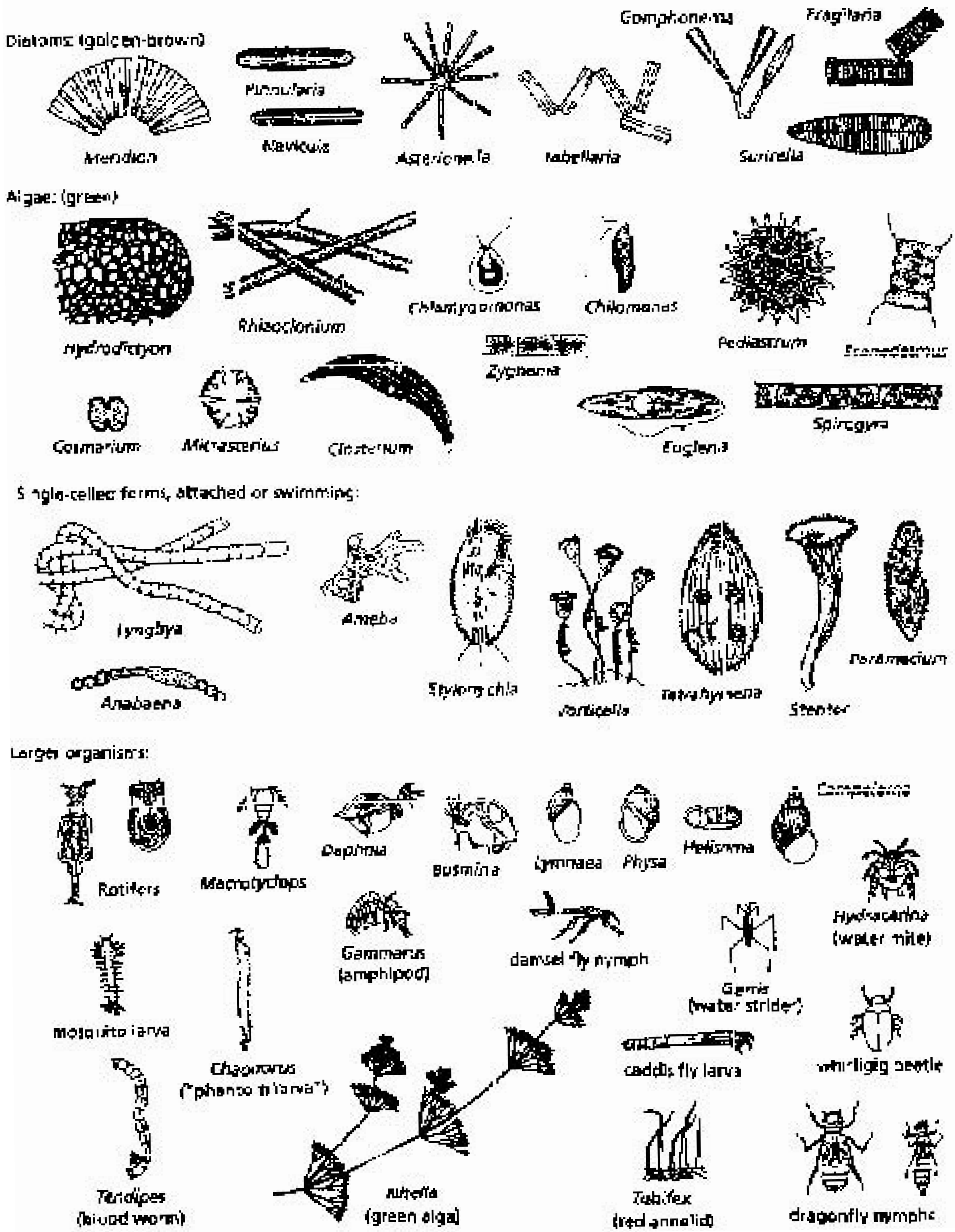
**Magnification Worksheet**

Name ______________________________

| | |
|---|---|
| **Actual size, 1x letter m**<br><br>m | **Size when m is viewed with 1 washer lens** |
| **Size when m is viewed in focus with 3x hand lens** | **Predicted size of m when viewed with 3 washer lens** |

**Actual size when m is viewed with 3 washer lens**

# Pond Life Identification



Teacher Information Only *

| **Characteristic** | **Kingdom** | | | | |
|---|---|---|---|---|---|
| | Monera (bacteria) | Protista (protozoa and algae) | Fungi (molds, yeast, mushrooms, rust, smuts) | Plantae (non-microscopic plants) | Animalia (non-microscopic animals) |
| **cell type** | prokaryotic (cells lacking distinct membrane-bound nuclei) | eukaryotic (cells containing membrane-bound nuclei) | eukaryotic (cells containing membrane-bound nuclei) | eukaryotic (cells containing membrane-bound nuclei) | eukaryotic (thick cell wall) |
| **body form** | most unicellular; some colonial | most unicellular; some multicellular | most unicellular | mulitcellular | multicellular; organs, and organ systems |
| **cell wall composition** | polysaccharides and amino acids | present in some | usually chitin | cellulose | no cell wall |
| **mode of nutrition** | photosynthesis, chemosynthesis absorption | photosynthesis, ingestion, or absorption | aborption | photosynthesis, | ingestion |
| **nervous system** | absent | absent | absent | absent | present |
| **locomotion** | present in some | present in some | absent | absent | present |

Do not have student memorize . This is not to be tested. *

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**Standard 05:**
Students will understand that microorganisms range from simple to complex, are found almost everywhere, and are both helpful and harmful.
**Objective 1:** Observe and summarize information about microorganisms.
**Objective 2:** Demonstrate the skills needed to plan and conduct an experiment to determine a microorganism's requirements in a specific environment.

**Activity 2: Microorganism Multiplication**

**Intended Learning Outcomes:** 1-Use science process and thinking skills
3-Understand science concepts and principles
4-Communicate effectively using science language and reasoning

Teacher Background:
Yeast are small, single-cell organisms. They are members of the kingdom *fungi* (singular, fungus), that also include mushrooms. Fungi differ from plants in that they have no chlorophyll. They have been useful to humans for centuries in the production of certain foods and beverages. They are responsible for the rising of bread dough and the fermentation of fruits and grains to produce alcoholic beverages. They also play the initial role in the production of vinegar. Most yeast can live only on sugars and starches. From these they produce carbon dioxide gas and alcohol. Yeast usually reproduce by a method called *budding*. A small knob or bud forms on the parent cell, grows and finally separates to become a new yeast cell. Although this is the most common method of reproduction, yeast also multiply by the formation of spores.

Yeast used in bread production is an example of fungi that causes fermentation. Yeast consumes the sugars present in bread dough to use the energy from the sugar for growth and reproduction. When the yeast consumes sugar, it is broken down into carbon dioxide gas and alcohol. Little bubbles of carbon dioxide released from the yeast fill the dough and cause it to expand or "rise." A slice of bread can be examined with the naked eye or with a magnifying glass to see the many small spaces made by the carbon dioxide.
Some yeast are able to grow at relatively low temperatures. In fact, the fermentation of wines and beer is often carried out at temperatures near 4°C (40° F). This can create a spoilage problem in

meat coolers and other refrigerated storage areas.

Because yeast can grow under conditions of high salt or sugar content, they can spoil certain foods in which bacteria would not grow. Examples are honey, jellies, maple syrup, and sweetened condensed milk. Foods produced by the bacterial fermentation process, such as pickles and sauerkraut, can also be spoiled by yeast which interfere with the normal fermentative process.

**Materials:**
- 3 - 125 ml Erlenmeyer flasks
- water
- hot plate or thermos
- flour
- sugar
- teaspoon yeast (rapid rise)
- balloons
- salt

**Invitation to Learn:**
Ask students what makes bread rise and under what conditions bread rises best. Explain to them that they will be using yeast and design an experiment to see what conditions are best for yeast to grow and thrive.

**Instructional Procedures:** 1. Explain to students we can measure the activity of yeast by collecting the gas they give off. More gas means more yeast are eating, reproducing and performing the functions of life. 2. To trap the the gas, a balloon will be placed over the mouth of a narrow-necked beaker (a 125 ml Erlenmeyer flasks works best) or a test tube. 3. Show students the "control" flask. Add 100 ml of warm water. Add 1/2 tsp yeast and a tsp of sugar. Place a balloon over the flask and swirl it.

4. Assign students to as many groups as possible and give them time to design an experiment on the yeast. Show them the materials that are available. They can change ONE variable in the experiment. For example, they could change the amount of sugar or use flour, honey, salt or powdered milk instead. Students may wish to try hot water (over 130˚F) or cold water. They may put in more or less yeast. Have them record in a journal or lab paper what they will change. 5. Give students time to set up their flasks and time for the yeast to grow and the balloons to expand. This may take 30 minutes or more.

Questions to answer during the experiment:
a. What do you observe in the first 5 minutes?
b. What do you observe in 20 minutes?
c. What do you observe in 60 minutes?

d. What is blowing up the balloons?
e. Yeast is added to bread dough. Why does the bread rise? f. What evidence do you see that yeast produce gas in bread?

Questions to answer after the experiment:
g. What group got the most gas? What did they change?
h. What group got the least gas? What did they change?
i. If you wanted to make bread rise the more quickly, what would you do?
j. Why would a baker need to understand the needs of yeast?

6. At the end of the experiment, your group should report to the class. Plan to explain what you did and what happened. Think of reasons why you got the results you did.

**Possible Extensions/Adaptations/Integration:**
Students may wish to make bread at home and try different conditions to see how it affects the rising time.

**Additional Resources:**
*Materials adapted from materials provided by Utah State University Extension and Utah Agriculture in the Classroom, www.agclassroom.org/ut.*

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**Objective 2:** Demonstrate the skills needed to plan and conduct an experiment to determine a microorganism's requirements in a specific environment.

## Activity 3: How Do You Make Perfect Yogurt?

This activity is preparing and consuming food in the classroom. Utah state law requires that a person with a food handler's permit be present when food is prepared for student consumption. Sanitary condition must exist, such as in a kitchen or cafeteria.

## Intended Learning Outcomes:

1-Use science process and thinking skills
3-Understand science concepts and principles
4-Communicate effectively using science language and reasoning
5-Demonstrate awareness of social and historical aspects of science

## Teacher Background:

What makes milk thicken to make yogurt? During biblical times, people in the Middle East discovered yogurt. They found that when milk was left in a warm place, it thickened and developed a different, tart flavor. More importantly, it kept better than fresh milk. It was centuries later that scientists discovered that tiny bacteria made yogurt. Most yogurts are made from either *lactobacillus bulgaricus* or *streptococcus thermophilus*. Once the bacteria are added to milk, these bacteria consume the milk sugars and undergo fermentation, much like the yeast in bread. The benefit of having a fermented milk product is that so much acid is produced by these organisms that few other potentially harmful microorganisms can grow in this acid yogurt environment.

Not all processors process yogurt the same. Live active cultures will be necessary for this bacteria experiment. Making yogurt in the classroom is best done as a demonstration - unless you can get several small "incubation" coolers for each group or team of students.

**Materials:**
- 1-3/4 cups powdered milk
- 4 cups of very warm water
- 1/3 cup of plain yogurt
- 5 one-cup containers with lids ( i.e., jelly jars, old yogurt containers, or other food cups with lids)
- mixing container
- whisk
- cooler (incubator)
- fruit topping or pie filling
- spoons
- litmus paper

**Invitation to Learn:**

Ask the children if they know of any items they can buy that is produced by microorganisms. One of the items they mention might be yogurt. Ask the children if any of them have yogurt makers at home. Have they ever made it at home? Is it hard? Is it easy? What might they think they need to make it? Why would heat be needed to make it? Can yogurt spoil if left outside the refrigerator after it is made? To find out, let's make yogurt in class.

**Instructional Procedures:**

Before you begin, make sure you have all the necessary ingredients: containers with lids (You can use previously used yogurt containers, or purchase 2 oz. cups with lids from any restaurant supply store or possibly your school cafeteria.), and a small insulated "cooler" that will be used as the incubator. Small "lunch tote" coolers work well, and many come with a container that you can fill with hot water that will surely keep your yogurt warm for the 6-8 hours it will need to incubate. Be sure to use a plain yogurt that contains active cultures. Taste the plain yogurt you plan to use as the starter culture. (Dannon works well.) Your yogurt will have the same taste. Making yogurt in your classroom is easy and really "fool proof" if you follow the recipe and procedures.

Ingredients

1-3/4 cups powdered milk

4 cups very warm water (between 43-51˚C, 110-125˚F)

1/3 cup plain yogurt with active culture and no additives (The yogurt will only taste as good as the starter you use.)

1. Whisk the first two ingredients until dissolved.
2. Add the yogurt and whisk until most of the clumps are dissolved. Work quickly, you don't want the mixture to cool.
3. Pour the mixture into the cups. 4. Before placing the containers into an insulated cooler for 6-8 hours, use one cup to conduct a few simple observations. What is the consistency, pH (use litmus paper), color and smell. Be sure to make these same observations after the incubation period. During this "incubation time" the bacteria will multiply, ingest the milk sugar (lactose), and thicken the milk turning the mixture into yogurt. One word of caution, yogurt will not thicken or will

separate if disturbed or bumped during the incubation period. Coagulation (thickening) changes the chemical makeup of protein so it is no longer water soluble (does not dissolve in water). Heat or acid at the proper temperature coagulates protein. In yogurt, protein is coagulated because acid is produced in a warm environment. If yogurt is moved during incubation (before yogurt is set), liquid and solid will separate.

5. After incubation, refrigerate, add fruit or other flavorings and enjoy!
6. Ask students to complete the "There are bacteria in my yogurt!" worksheet. Answers: 1) fermentation 2) bacteria 3) the sugars have been converted to an acid 4) liquid to solid as a result of fermentation, a chemical change 5) to get the bacteria to multiply (reproduce) more quickly 6) too hot, it would kill the bacteria, too cold and the bacteria would not become active, consume the milk sugar and ferment the milk 7) nothing, no bacteria, no yogurt 8) the acid condition of yogurt (lack of sugar) keeps other bacteria from a food source 9) food, water, proper temperature, proper acid level (pH), no inhibitors present, host.

**Possible Extensions/Adaptations/Integration:**

- Try some real world science. Allow your students to manipulate the recipe above to see how bacteria thrive best. See numbers 6 and 7 on the Microbe worksheet for more experimental ideas.

**Assessment Suggestions:**

-

**Additional Resources:**

Yogurt web sites: www.dannon.com

# There are bacteria in my yogurt!

Name______________________________ Date____________________ Class/Hour______________

1. What process caused a change in the original milk that you began with?

2. Why did you add a small amount of store-bought yogurt to your milk? What did this addition introduce into your milk mixture?

3. Why does the yogurt taste different from the original milk?

4. What changes occurred as the milk changed to yogurt? What caused these changes?

5. Why did the yogurt mixture need to be incubated in a warm container?

6. What if the milk mixture had been too hot or too cold, would the yogurt had set?

7. What would happen if the yogurt culture did not contain active cultures?

8. Why does yogurt keep better than fresh milk?

9. What are six things bacteria need to survive?

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## <u>Activity 4:</u> Microbe Experimentation: Sour Milk

Intended Learning Outcome:

1-Use science process and thinking skills

4-Communicate effectively using science language and reasoning

6-Understand the nature of science

### <u>Teacher Background:</u>

Pasteurization is a heat treatment and is performed at milk processing plants. Pasteurization destroys harmful bacteria without affecting the quality of the milk. Milk may be pasteurized using a low heat method (63°C, 145°F for 30 minutes) or a high heat method (72°C, 162° F for 15 seconds). Pasteurization does not kill all bacteria contained in raw milk, but it does kill those that may cause disease. Bacteria that remain after pasteurization eventually cause milk to sour (spoil). Pasteurization also inactivates enzymes in the milk and destroys yeasts, molds, and other bacteria.

Bacterial populations in milk are a direct indication of milk quality. Processing plants check the milk before they load it into a truck, again before the truck is unloaded at the processing plant, in the storage tank at the processing plant, before it is pasteurized, and after it is pasteurized. Milk lots are also tested daily for 10 days after they are bottled. There are two tests used primarily. The first test checks the concentration of microorganisms in raw and pasteurized milk. The second test detects viable and dead microorganisms.

In both pasteurized and raw milk, various microorganisms succeed one another as the chemical environment of the milk changes. The microbes themselves bring about these changes.

Milk sours in stages as one type of bacteria is replaced by another. Bacilli convert protein into ammonia products, and the pH rises. The odor of spoiled milk becomes apparent once this has happened.

UHT or "ultra high pressure" treated milk is milk that is "ultra" pasteurized, making the milk sterile. Ultra high temperature, higher than pasteurization, and pressure is applied to the milk resulting in a sterile product that can be stored without refrigeration. UHT milk is specially packaged in airtight containers. UHT milk may be difficult to obtain locally. Powdered milk that has been reconstituted can be substituted. Powdered milk is not a "sterile" product, but when prepared with clean water it is nearly "sterile".

**Materials:**

*For Each Team of 3 to 4 Students*

- 3 to 6 test-tube racks, depending on the number of teams. Teams can share test-tube racks.
- Refrigerator with freezer compartment, if possible
- 30 ml of pasteurized, whole milk (10 ml/test tube)
- 30 ml of ultra high temperature milk (shelf stable, UHT) or reconstituted powered milk
- 6 sterile test tubes
- 6 sterile test-tube caps or aluminum foil to cover the test tubes
- Two sterile 10 ml pipettes
- One or two sterile 5 ml pipettes or eye droppers
- 20 Sterile plastic pipettes
- Methylene blue 1%
- Permanent marker to label test tubes

**Invitation to Learn:**

Ask students if they have ever poured a glass of milk and taken a big sip only to discover it tasted awful. Have they have ever wondered why their parents are always asking them to put the milk back in the refrigerator? What might happen to that milk if it's left out at room temperature overnight? What might be present in milk, that if left out, may cause the milk to spoil? Explain that this activity will help them understand the reasons behind milk spoilage.

**Instructional Procedures:** *Preparation*

Prepare the lab by sterilizing the test tubes, test-tube caps, pipettes (if using glass and not plastic sterilized pipettes). Purchase pasteurized whole milk and ultra high temperature (shelf stable) whole milk or powdered milk. (Shelf stable UHT milk can usually be found in the juice aisle. Ask your store manager to order it if it isn't available in your supermarket.)

Pour a small amount of methylene blue into dropper bottles. Place all the equipment on a lab table. Provide each student with "Blue's the Clue" data table. Discuss pasteurization and UHT (shelf stable) or powered milk with students.

*Design and Conduct Experiment*

1. Introduce the materials teams may use for their experiments: regular pasteurized milk, ultra high temperature (shelf stable) milk or powdered milk, and methylene blue. Tell them they can use any of the other materials on the lab table. Also mention there is a refrigerator and freezer they can use.

2. Explain that one container of milk came from the refrigerated dairy case of the supermarket and the other from an unrefrigerated shelf. Let students examine each containers.
3. Explain to students that methylene blue is an indicator dye used to determine the presence of bacteria in milk. It will turn the milk blue at first and as bacteria alter the milk it will turn white again. Students should add enough drops of methylene blue to turn the milk blue (2-3 drops).
4. Ask students to form teams of 3 or 4 and encourage each team to develop a hypothesis on how temperature affects bacterial growth. Then ask them to design an experiment to test their hypothesis.
5. Let teams discuss their hypotheses and experimental designs for 10 to 15 minutes. Then, begin posing the following questions to help students design well-thought-out experiments:
   - What are some variables you could test? *(storage temperature, milk type)*
   - How many variables can you test in one experiment? (*ONE)*
   - What will be the control? *(a part of the experiment left unchanged, for example, if temperature is being tested, the control would be in the refrigerator, the test sample should be left out at room temperature)*
   - How can you tell if bacteria are growing in the test samples? *(Add methylene blue to each sample. If bacteria are growing, the methylene blue will become colorless and the milk will change from blue to white. This is not immediate, but happens over a few days.)*
6. Have each group present their hypothesis and experimental design to the class. Encourage students to discuss the merits of each suggested test. *(Students will often want to test temperature and milk type together in the same experiment. This should be discouraged because the results will not be clear.)*
7. After the group discussions, give the teams time to revise their hypotheses and experimental designs.
8. Let teams conduct experiments according to their designs. *Note: The test tubes must be checked each day after the experiment has begun. Since the color change happens over time, you could miss important findings if you don't check every day. Students should design data collection charts and tables to record information.)*

Observe and Record

1. Students should make daily observations and record their results in journals or lab sheets. They can make drawings or written observations
2. Have teams present their findings to the class. They should report their results and discuss ways they would improve their experimental design.
3. Remind students to include the relationship of their findings to food safety.

Results you can expect from this experiment:

Room temperature samples

- The pasteurized milk will turn white on the second day indicating that there are some spoilage bacteria in milk. At a temperature conducive to bacterial growth, they will multiply.
- The UHT milk will still be blue by the second day. This is because the UHT milk has fewer spoilage bacteria than regular pasteurized milk. Thus, it takes longer to see any bacterial growth. Bacteria do not quickly multiply in the UHT milk.
- After leaving the UHT milk at room temperature for another day or two, the color will turn white, indicating that spoilage bacteria will ultimately grow in the UHT milk.

Chilled and frozen samples

• Both the pasteurized and UHT chilled and frozen milk samples will still be blue by the second day, indicating that cold temperatures retard bacterial growth. • After leaving the chilled and frozen samples at room temperature for another day or two, the color will change to white. This indicates that when the temperature rises to room temperature bacteria can grow. It may take longer for the UHT milk to change to white because there are fewer spoilage bacteria in UHT milk than in regular pasteurized milk.

**Possible Extensions/Adaptations/Integration:**

1. Compare the spoilage rate and bacterial growth in milk samples of varying fat content, such as powdered, skim, 1%, 2%, whipping cream, canned milk, and half-and-half. 2. Study and discuss the numerous contributions of Louis Pasteur. (See references.)
3. Test UHT milk that has an expiration date that has passed and UHT milk that has an expiration date in the future. See if the "expired" milk changes more quickly than the fresher milk.

**Additional Resources:**

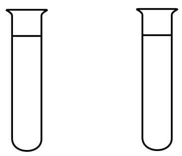
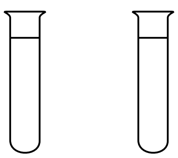
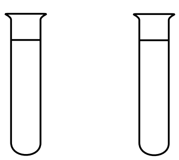
Methylene blue 1% (Educational Reagent Aqueous Solution available at most science supply stores or catalogs)

The Importance of Louis Pasteur
Author: Lisa Yount. 1994
Publisher: Lucent Books, P.O. Box 289011, San Diego, CA, 92198.

Science and our Food Supply
Instructional Unit and video, Published by FDA and NSTA, 2001. Order ***free*** copy from www.foodsafety.gov/‘fsg/teach.html

## Blue's the Clue Observation Sheet

Name________________________________ Date_______________ Class/Hour______________

| Day 1<br>Original Sample | Day 2<br>Describe Visual Changes | Day 3<br>Describe Visual Changes | Day 4<br>Describe Visual Changes |
|---|---|---|---|
| Room Temperature<br><br>Pasteurized Milk Powdered Milk | Pasteurized:<br><br>Powdered Milk: | Pasteurized:<br><br>Powdered Milk: | Pasteurized:<br><br>Powdered Milk: |
| Refrigerated<br><br>Pasteurized Milk Powdered Milk | Pasteurized:<br><br>Powdered Milk: | Pasteurized:<br><br>Powdered Milk: | Pasteurized:<br><br>Powdered Milk: |
| Frozen<br><br>Pasteurized Milk Powdered Milk | Pasteurized:<br><br>Powdered Milk: | Pasteurized:<br><br>Powdered Milk: | Pasteurized:<br><br>Powdered Milk: |

1. How did the data support or reject your hypothesis?

2. What do you predict will happen if the dry samples are left at room temperature for another day?

3. What do you predict will happen if the dry samples are left at room temperature for another day?

4. Explain the relationship of your findings to food safety.

**Science Benchmark: 06 :05**

Microorganisms are those things that are visible as individual organisms only with the aid of magnification. Microorganisms are components of every ecosystem on Earth. Microorganisms range in complexity from single to multicellular organisms. Most microorganisms do not cause disease and many are beneficial. Microorganisms require food, water, air, ways to dispose of waste, and an environment in which they can live. Investigation of microorganisms is accomplished by observing organisms using direct observation with the aid of magnification, observation of colonies of these organisms and their waste, and observation of microorganisms' effects on an environment and other organisms.

**Standard 05:**

Students will understand that microorganisms range from simple to complex, are found almost everywhere, and are both helpful and harmful.

**Objective 3:** Identify positive and negative effects of microorganisms and how science has developed positive use for some microorganisms and overcome the negative effects of others

Activity 5: Good Guys or Bad Guys

**Intended Learning Outcome:**

1-Use science process and thinking skills
3-Understand science concepts and principles
4-Communicate effectively using science language and reasoning
5-Demonstrate awareness of social and historical aspects of science

**Teacher Background:**

Yes, it's true; decomposition is a fundamental process on which all life depends. We'd all be knee deep in garbage without it. Bacteria, fungi, and other microscopic organisms that live in the soil, air, and water are responsible for turning once living plants, animals and other organisms into nutrients that can be used again and again. Think of them as nature's recyclers. These tiny creatures have the ability to produce special enzymes that allow them to break down dead plant and animals and use them as food. No job is too big because they enlist the help of friends and family. As they eat, they grow and multiply at an amazing rate. In just 4 hours, one bacterial cell can grow to a colony of 5,096. At day's end there are millions and billions of them working together. Why, in 1 teaspoon of soil, there are more bacteria and fungi than all the people on Earth!

Some microorganisms are harmful and cause disease while others are benevolent, neutral, or even helpful. Some help us to produce certain foods, break down toxins in our environment, while others can kill us. For example: Protozoa cause amebic dysentery, fungi cause athlete's foot and ringworm, bacteria cause pneumonia, legionnaire's disease, strep throat, tetanus and other diseases. Contaminants in food like *E. coli* or *Salmonella* can also make us very sick. The second activity in this lesson will focus on helpful and harmful microorganisms.

Molds:

Molds are probably the best known of the microorganisms (see bread mold activity in previous lesson). They are widely distributed in nature and grow under a variety of conditions in which air and moisture are present. They are members of the kingdom fungi. Nearly everyone has seen mold growth on damp clothing and old shoes. The mold we see with the naked eye is actually a colony of millions of mold cells growing together. Molds vary in appearance. Some are fluffy and filament-like; others are moist and glossy; still others are slimy.

Molds are made up of more than one cell. They appear flat, fuzzy, and shapeless. Mold cells form a "fruiting body." The fruiting body produces the spores, which detach and are carried by air currents and deposited to start new mold colonies whenever conditions are favorable. Mold spores are quite abundant in the air. So any food allowed to stand in the open soon becomes contaminated with mold if adequate moisture is present. Some types of molds are also psychrophiles (grow in cool temperatures) and can cause spoilage of refrigerated foods.

Molds (and other microorganisms) are important to the food industry. Among their many contributions are the flavor and color they add to cheeses and the making of soy sauce. They also play a role in making chemicals such as citric and lactic acid and many enzymes. Sour cream, buttermilk, yogurt, and hard cheeses (cheddar, Swiss, jack, feta, etc.) are all cultured with a bacteria. Other cheeses such as blue and Roquefort are cultured by fungi. Processed cheeses, like American cheese, are not cultured with microorganisms.

Some ice cream contains a thickener made from seaweed. Seaweed, or algae, is everywhere in our food today. Chunks of it float around in Korean soups, paper-thin sheets of it are wrapped around Japanese rice balls, and it lies hidden in the alginates and carrageenans in hamburgers, yogurt and ice cream. Seaweed-based food additives are now so commonly used in prepared and fast food that virtually everybody in Europe and North America eats some processed seaweed every day.

Sometimes microorganisms spoil food. Most students will have seen rotten, spoiled, or moldy food in their refrigerators. Food that is spoiled by bacteria may not be seen with the naked eye, but the food will taste bad and can make you sick. Molds are more visible. The best known use of molds is in the drug industry, where they help produce such antibiotics as penicillin.

The old adage for dealing with questionable food is the best advice, "When in doubt...throw it out!"

## Activity A: Decay and Decomposition

**Materials:**

- quart Ziploc bag for each team of two
- clear tape

• markers
• decay buffet (including grass, vegetable peelings, straw, dry leaves, etc.)
• water spray/mist bottle • food handler's gloves
• magnifying glasses

**Invitation to Learn:**

Ask students to describe the most disgusting thing they have ever pulled out of their refrigerators. Ask them why foods decay and see if molds or bacteria are mentioned. Ask students if they ever eat molds or bacteria. Explain to them that in this activity they will see how microorganisms are both helpful and harmful to the food industry.

**Instructional Procedures:**

1. Divide the class into pairs.
2. Provide each pair of students with a locking plastic quart bag and ask them to write their names on some tape and then stick the tape on the bag.
3. Set up a "Decay Buffet" of items noted in the list of materials to be placed in the bags. The ingredient ratio of 2-parts dry (brown or the carbon containing ingredients) to 1-part wet (green or nitrogen containing ingredients) is VERY IMPORTANT.
4. Students should place one small piece of each item at the "Decay Buffet" into their bags. Have them cut up items if necessary. *Stress that they not add any meat or dairy product to their bags because potentially harmful bacteria could grow*.
5. One student can place the items in the bag and the other student can record the exact contents.
6. The recorder should also note his/her partner's predictions as to what will happen to each item over time. Will the item rot? Smell yucky? Remain the same?
7. *Optional*. You may want the students to switch roles and create a second compost bag with a list of contents and predictions.
8. Ask the students to add about 1/2 cup of soil to their bags and to lightly mist the contents with a plant mister. (Adding a teaspoon of water and mixing the contents will work the same way.)
9. Have the students blow into the bags (to inflate slightly) and carefully seal the bags.

*Once the bags are sealed, leave them for 2-8 weeks. You may decide to keep the bags together, or place them in various locations with differing conditions. (If you let the students choose their compost bag's location, be sure to have everyone register their locations on a class master list or you may be unpleasantly surprised when a missing bag finally makes its presence known.)*

10. Have students create compost bag journals. Ask them to observe their bags periodically and record what they see happening inside. Do they see fuzzy masses? Remind students that they are not to open the bags until the designated date.
11. On the designated date, have the students take their bags outside. Distribute plastic gloves to the students to wear while sorting through the contents of their bags with their partners. They may need magnifying glasses to "see" the original items. *Caution: students with known allergies to mold or fungus should not participate!* Bags do not need to be opened to observe mold growths and decay.
12. Record any items still identifiable and in their present state. Provide misters or water bowls so

items can be cleaned off for closer observation and identification.
13. Are any items missing? Check the list and note the items missing.
14. How did the results compare with the predictions?
15. Define and discuss the process of decomposition or decay.

You may want to ask your students some questions: 1) What are some things you have thrown away over the past couple of days? What happens to these things? Do they disappear? Decompose? Remain in the same form forever? 2) Will placing the bags in various conditions have an effect on what occurs in the bags? 3) Can you think of any other types of compost containers that would get the decomposition job done?

“Bottle Biology” published by Kendall/Hunt Publishing, includes plans for making compost tumblers, the “Decomposition Column,” out of 2-liter bottles. Pickling bottles “vats,” making your own microscope, and other great science projects are included in this book. See the Resource section for ordering information.

Making compost can be very educational whether you are studying soils, plant growth, gardening, microbiology, or just trying to reduce waste.

## Activity B: Microbes in My Food

**Materials:**

- grocery store newspaper advertisement
- bread wrapper
- label from a box of cereal
- beef jerky package label
- yogurt container
- package from dried fruit
- copies of Microbe Grocery List

**Instructional Procedures:**

1. Arrange the students in pairs.
2. Provide each pair with a grocery store advertisement and the “Microbe Grocery List.”
3. Instruct them to find all the foods in the ad that have a relationship to microorganisms, and write them down. Remember foods like spaghetti sauce may contain mushrooms, and foods containing dough have yeast.

4. Ask each group to share with the class the food products they found in their ad. Did they miss any? Did other groups find the same products? Can these foods be spoiled by other microbes and make us sick?
5. Explain to students that virtually all foods can spoil or be contaminated. That is why you find food additives, or inhibitors, or preservatives in food, to keep them fresher or viable longer.
6. Read the labels of the food items listed in the materials list.

Ask the following questions:

- Can you identify an ingredient that might be a food additive or preservative? *(Sometimes sugar, salt, or vinegar is added to a product to inhibit the growth of microorganisms, a chemical preser-*

*vative may be added to do the same thing but will have little effect on the flavor of the food. For example, jelly is so sweet that few additives need to be added to preserve freshness; the sugar acts as a "natural" preservative, the same with pickles and vinegar.)*

- Is the food preservative the same from item to item? *(No, because some food additives or inhibitors only work on certain microbes, see the Food Preservation Techniques Information page.)*

**Possibe Extensions/Adaptations/Integration**

Activity A: Stomach Microorganisms:
*Why Can a Cow Eat Grass?*

"Why Can a Cow Eat Grass?" from Utah Agriculture in the Classroom
www.agclassroom.org/ut

Activity B: Good, the Bad, and the Ugly
Ask students to make two lists: The Good Things About Microorganisms and The Bad Things About Microorganisms. Ask students to add to the list and make changes, as they continue to learn about microorganisms.

**Additional Resources:**

*Bottle Biology*, Kendall Hunt Publishing (www.kendallhunt.com)

Microbe Grocery List

*Look through a grocery store advertisement and find see how many foods you can find that contain microorganisms or were produced with the help of microorganisms. Be sure to make the connection between vinegar and salad dressing. Many salad dressings may also include a thickener from algae. Pizza has dough, so it has yeast, etc. Are there any foods on sale that without proper handling may make you sick?*

**Common Microbes found in foods**

Bacteria: Cheddar cheese, Swiss cheese, feta, sour cream, buttermilk, yogurt, vinegar
Fungi: Blue Cheese, Mushrooms
Algae (Protista): Ice Cream, salad dressings
Yeast: Bread, and other dough products
*available for plant growth. Microorganisms are great recyclers!)*

Additional Resources
Bottle Biology
Kendall Hunt Publishing (www.kendallhunt.com).

**Microbe Grocery List**

*Look through a grocery store advertisement and see how many foods you can find that contain microorganisms or were produced with the help of microorganisms. Be sure to make the connection between vinegar and salad dressing. Many salad dressings may also include a thickener from algae. Pizza has dough, so it has yeast, etc. Are there any foods on sale, that without proper handling, may make you sick?*

**Common microbes found in foods**
Bacteria: cheddar cheese, Swiss cheese, feta, sour cream, buttermilk, yogurt, vinegar
Fungi: blue cheese, mushrooms
Algae (Protista): ice cream, salad dressings
Yeast: bread, and other dough products

| Food Items | Microbe Responsible | Price | Does this food product need special handling (i.e. refrigeration) to keep from spoiling? |
|---|---|---|---|
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Food Preservation Techniques

***Canning*** first destroys bacteria through heating and then the food is placed in a sterilized container and sealed.

***Drying*** removes water from the food that bacteria need to grow and reproduce.

***Freezing*** slows down the spoilage process by changing water into ice; a form that the bacteria cannot use.

***Pasteurization*** destroys most of the existing spoilage organisms by heating the food to a high temperature for a short duration.

***Pickling or fermentation*** (culturing) leaves the food with a higher level of acid, making it an inhospitable environment for spoilage bacteria.

***Vacuum packaging*** uses a vacuum sealed, abrasion-resistant moisture-impermeable film that inhibits molds, yeasts, and bacterial growth on the surface of the things such as meat. Since there is no air in the package, vacuum-packaged meat will have a darker, purple color before being opened. Once the meat is exposed to oxygen, it will turn the familiar bright red color, because of the natural reactions within the package. Fresh vacuum-packaged meat will give off a slight odor when opened. The smell will dissipate within a few minutes. This should not be confused with spoilage.

***Smoking*** adds smoke-born chemicals to food that help destroy potential spoilage organisms.

***Chemical additives*** are designed to destroy spoilage organisms or inhibit their growth. Sugar and salt are examples of additives that have been in use for centuries. Both of these work by drawing water out of the spoilage organisms, thus preventing their growth.

***UHT*** (ultra-high temperature) uses heat higher than pasteurization: then pressure is applied resulting in a sterile product.

***Irradiation*** is a process that pasteurizes food by using energy, just like milk is pasteurized using heat. Irradiation DOES NOT make food radioactive. The food never touches a radioactive substance. Irradiation destroys insects, fungi, and bacteria. Fewer nutrients are lost during irradiation than in cooking and freezing. Food irradiation has been approved in 37 countries for more than 40 products. Astronauts have eaten irradiated foods for years.

***Food additives*** are any substances added to food. Sugar, salt, and corn syrup are the most commonly used food additives. Food additives keep foods fresh, slow microbial growth, give desired texture and appearance, and aid in processing and preparation.

**Science Benchmark: 06 :05**

Microorganisms are those things that are visible as individual organisms only with the aid of magnification. Microorganisms are components of every ecosystem on Earth. Microorganisms range in complexity from single to multicellular organisms. Most microorganisms do not cause disease and many are beneficial. Microorganisms require food, water, air, ways to dispose of waste, and an environment in which they can live. Investigation of microorganisms is accomplished by observing organisms using direct observation with the aid of magnification, observation of colonies of these organisms and their waste, and observation of microorganisms' effects on an environment and other organisms.

**Standard 05:**

Students will understand that microorganisms range from simple to complex, are found almost everywhere, and are both helpful and harmful.

**Objective 3:**

Identify postive and negative effects of microorganisms and how science has developed positive uses for some microorganisms and overcome the negative effects of others.

Activity 5: Microbes and Health

**Intended Learning Outcome:**

1-Use science process and thinking skills
3-Understand science concepts and principles
5-Demonstrate awareness of social and historical aspects of science

**Teacher Background:**

This lesson is designed to acquaint students with the concept of how microorganisms cause disease. Many diseases are caused by microorganisms, little creatures too small to see. A large number of microorganisms thrive in water. They include bacteria, viruses, and protozoa. Infected people may pass them by sneezing, hand contact, or through sewage. Usually microorganisms cannot be seen, smelled, or tasted.

Many deaths in developing countries are caused by diarrhea and related dehydration. Poor sanitation contributes to the spread of bacterial disease, such as cholera, food poisoning, and shigella (*shigellosis*). Bacteria are everywhere, including our water supplies. Water supplies in the U.S. are tested and treated regularly, so we can normally drink water without concern. However, waterborne diseases are common in many other parts of the world where water is not tested and treated.

Grocery stores and restaurants in the United States must follow many health standards concerning food safety. They are responsible for providing us with quality, safe food. Health inspectors routinely inspect these stores and restaurants to make sure they are following the guidelines. If health inspectors find that a business is not in compliance, they can penalize them by closing the business for a specific amount of time or perhaps indefinitely.

In the United States, we are fortunate to have a government that makes food safety a priority. In some countries food may be produced or imported, but it is spoiled by pests or microorganisms due to poor storage techniques. Pests (insects and rodents) and microorganisms (bacteria, mold, yeast) are the two chief causes of food spoilage. Food must be transported, stored, and prepared correctly to ensure safety.

All food will spoil if it is not preserved in some way. Some foods such as nuts and grains can be stored for a long time without spoiling. Other foods such as bread and milk must be consumed quickly. Foods can be preserved in many ways. Canning, freezing, and dehydrating are just a few methods. Spoilage may occur before there is a change in taste or odor. Therefore, consumers should read expiration dates before eating food products bought from grocery stores.

People can reduce their risk of food-borne illness by handling it properly. Eighty-five percent of the cases of food-borne illness caused by bacteria can be avoided with proper food handling. Keys to food safety are washing hands, checking expiration dates, washing surfaces and utensils with hot, soapy water, refrigeration and freezing, rinsing fruits and vegetables, and storing foods in proper places.

## Activity A: How Did I Get Sick?

**Materials:**

- cups of water (one per student)
- sodium hydroxide solution or liquid ammonia cleaner
- phenolphthalein
- eye dropper

**Invitation To Learn:**

Begin the lesson by discussing worldwide causes of death. Be sensitive to students in your class who may have had a tragedy in their lives. If this strikes too close to home for them, skip this invitation. List student-suggested causes on the chalkboard. Indicate that the number one killer is diarrhea. Worldwide, thousands of children die of diarrhea each year. This is not the case in the USA because of proper sanitation and food and water purity.

**Instructional Procedures:**

1. Invite a volunteer to take a drink from either of two glasses of water. Tell him/her you spit into one glass before class. (optional) Discuss the response and reasons why we don’t drink water we think is contaminated.
2. Continue the exploration by indicating that the class is going to play a “kissing game.” Distribute the pre-prepared glasses of liquid to each member of the class. Prior to class time, add 1/8 teaspoon of sodium hydroxide to two of the glasses of water. *CAUTION: Warn students not to taste*

*any of the samples.)* Each student should have a glass of liquid. Indicate that you are going to exchange water from the cups ("kiss"). The procedure is to allow someone to pour some water from their glass into yours. For each amount added, each individual must pour this amount into another person's glass. Continue this exchange for three minutes.

4. After the water exchange, indicate that two of the cups contained germs (a chemical, ammonia or sodium hydroxide). As with most microorganisms, it is not easily seen but can be detected with a chemical. Speculate on how far you think the germ was spread during the three minutes.
5. Add a few drops of phenolphthalein to each glass. If the germ (ammonia or sodium hydroxide) is present, the water will change color. Those with colored water will have been infected. Discuss the results.

## Activity B: What is My Diagnosis?

**Materials:**

- copy of Symptoms Cards (see following page)
- copies of Waterborne Disease Analysis Key (one per student)
- create overhead transparencies of enlarged symptom card removing the disease names at the end of each description.

**Instructional Procedures:**

1. Indicate that some class members have exhibited some alarming symptoms or role play with students some "make believe" symptoms you are having. Let them know that you have reason to believe that some microorganisms caused the diseases.
2. Separate the class into seven cooperative learning groups. Distribute one Symptoms Card to each group and the Waterborne Disease Analysis Key to each student.

NOTE: *If students have not previously used dichotomous keys, acquaint them with procedures before continuing*.

3. Have a reporter from each group share their group's Symptom Card information using the overhead transparency as a visual aid for the entire class to view. Each group should then use this information to key the disease. Do this for all seven Symptom Cards.

## Activity C: Wash Your Hands!

**Materials:**

- cooking spray or vegetable oil
- cinnamon
- soap
- paper towels
- warm faucet water
- cold faucet water

**Instructional Procedures:**

1. Talk with the students about safe food handling practices at their homes. Do they thoroughly wash dishes? Do they refrigerate food properly? Do they look for expiration dates on packages? Do they wash their hands with soap and warm water?

2. Use this activity to show students the importance of washing hands with soap and warm water.
 a. Apply cooking spray or vegetable oil to each student's hands. *(Or you may choose to use a couple of volunteers to demonstrate the activity.)*
 b. Sprinkle cinnamon on the palms, backs, and in-between each student's hands. The cinnamon represents germs that get on our hands.
 c. Try to get rid of the cinnamon using only cold water. Discuss the results.
 d. Try to get rid of the cinnamon using soap and cold water. Discuss the results.
 e. Try to get rid of the cinnamon using soap and warm water. The cinnamon "germs" will rinse right off the student's hands and into the sink.
 f. Ask the students why the cinnamon stayed on their hands until they used soap and warm water. How is this similar to washing germs off our hands? Is it important to use soap and warm water for hand washing?

**<u>Possible Extensions/Adaptations/Integration:</u>**

Activity A: Guess My Microbe

1. Explain to your students that they are going to design a "Get a Clue, Guess My Microbe" riddle.
2. Assign each student a disease caused by a microbe and ask him/her to investigate his/her microbe by using the Internet or other library resources. *Students should not tell each other what disease they have drawn.*
3. Ask student to read their clues out loud to the class and see if they can guess the disease.

Activity B: Other diseases for further research

Botulism, Campylobacteriosis, Listeriosis, Perfringens, Salmonellosis, Shigellosis, Staphylococcal, Boils, Gonorrhea, Meningitis, Pneumonia, Scarlet Fever, Strep Throat, Anthrax, Diphtheria, Plague, Tetanus, Typhoid Fever, Cholera, Syphilis, African Sleeping Sickness, Malaria.

*Activity C: Show Them the Germs! Glo Germ™*

1. Purchase Glo Germ™ oil liquid and or the powder and a UV lamp (order materials from Glo Germ™ 1-800-842-6622 "http://www.glogerm.com" [www.glogerm.com](http://www.glogerm.com)). These materials illustrate (with the aid of a UV light) how germs are spread and emphasizes the importance of proper handwashing. Glo Germ™can help student to visualize "germs." Glo Germ™ products are made of tiny plastic particles that are only visible under an ultraviolet light. The florescent glowing particles represent "germs."
2. Before class, rub some Glo Germ™ liquid or powder on your hands. Shake hands with students as they enter your classroom. About halfway through class, students should place their hands under an ultraviolet light. Their hands will be glowing, indicating that the teacher's "germs" were passed to them. Furthermore, anything the students touched with their hands will be glowing and will show how quickly germs can spread.
3. As an exercise to teach proper hand washing, students can rub some Glo Germ™ on their hands. Then, they should repeatedly wash their hands for varying lengths of time. After washing their hands, any remaining germs, especially under fingernails, will be visible under the ultraviolet

light.

**Additional Resources:**

*Infection Detection Protection*, (student magazine), Published by the American Museum of Natural History, purchase a classroom set for $25. E-mail your request to center@amnh.org, or visit www.amnh.org/nationalcenter/infection/ for an interactive microbe experience.

Disease Background Information

**Enterotoxigenic** *E. coli* Gastroenteritis, caused by E. coli bacteria:

Leading cause of infant death worldwide. Visitors to Latin American countries who partake of the food and water occasionally come down with "traveler's diarrhea," also known as "turista" or "Montezuma's Revenge." A large outbreak of this disease occurred in 1975 in Crater Lake National Park, Oregon. About 2,000 park visitors and about 200 park employees became ill after consuming water that had been contaminated by sewage. Campers who drink from springs frequently contract this disease.

**Typhoid Fever**, caused by *Salmonellatyphi* bacteria:

Now uncommon in the U.S., this is usually acquired during foreign travel. During the first half of this century it was the most commonly reported cause of waterborne disease in the U.S. It can be acquired by contact with contaminated water, swimming, etc. In 1907, Mary Mallon, nicknamed "Typhoid Mary," was identified as a carrier of the disease. She transmitted the disease while working as a cook in restaurants and private homes in New York City. She escaped authorities for eight years, but was finally apprehended in 1915. She infected some 50 people, with three cases resulting in death. In 1973 a major outbreak of typhoid fever affected 225 people in a migrant labor camp in Dade County, Florida. The well that supplied water to the camp was contaminated by surface water.

**Giardiasis**, caused by *Giardia lamblia* protozoan:

Sickness results with a low dose of the protozoan. Today it is the most common reported waterborne disease. Normal hosts for the parasite are mammals such as beavers, muskrats, and raccoons. The giardia protozoan is killed by boiling water for at least five minutes.

**Legionnaire's Disease**, caused by *Legionella pneumophilia* bacteria:

Can occur naturally in water environments. Bacteria often colonize in artificial water systems such as air conditioners and hot water heaters, and can be inhaled with aerosols produced by such systems. Smoking and lung disease increase susceptibility to the disease.

**Salmonellosis**, caused by a species of *Salmonella* bacteria:

This is carried by humans and many animals; wastes from both can transmit the organism to water or food. The largest waterborne salmonella outbreak reported in the U.S. was in Riverside, California, in 1965 and affected over 16,000 people.

**Shigellosis**, caused by a species of *Shigella* bacteria:

Most infection is seen in children 1-10 years old; a very low dose can cause illness. Waterborne transmission is responsible for a majority of the outbreaks. It is quite common in the United States.

***Hepatitis A***, caused by *Hepatitis A* virus:

**Patient #1 Background**

Returns home from vacation in Central America. Problems start about 12 hours after drinking water in Central American restaurant. Diarrhea begins and ultimately causes dehydration. Muscles are tender and sore. Slight fever develops. Some nausea and vomiting occurs. Stomach and abdominal cramps cause increased discomfort.

**Gastroenteritis**

**Patient #2 Background**

Problems begin about 10 days after patient drinks from the same water glass as a family member who contracted a disease while visiting Africa. It becomes difficult for the patient to do any physical work (lethargic). Rose-colored spots appear on the skin. There are general aches and pains. Patient gets weaker (malaise), and loses appetite. Abdomen is tender to the touch. High fever develops and patient becomes delirious.

**Typhoid Fever**

**Patient #3 Background**

Symptoms start two weeks after a hike in the mountains. Patient drank water from a clear, cold mountain stream where there was evidence of beaver activity. Abdominal cramps begin. Bowel movement is greasy and foul-smelling. Patient experiences excessive intestinal gas. General weakness and discomfort ensues (malaise). Patient loses weight.

**Giardiasis**

**Patient #4 Background**

Patient is a heavy smoker. He/she likes house cool, so uses the air conditioner and keeps windows closed. Sudden fever rises to 104˚F. Patient gets chills, and notes that his/her breathing is very rapid, and a cough develops. There is a rattling sound in the lungs, and pains in the chest. Patient experiences general muscle pain and tenderness. Mental confusion and severe headaches occur.

**Legionnaire's Disease**

**Patient #5 Background**

Patient develops symptoms 10 hours after eating a poorly cooked hamburger. General discomfort and weakness occur (malaise). Fever increases. Stomach cramps with dysentery is followed by nausea and vomiting.

**Salmonellosis**

**Patient #6 Background**

Patient is a four-year-old child. Symptoms begin the day after the patient attends a friend's birthday party. Patient shared food with other children, and now has severe abdominal cramps, and frequent painful dysentery. Blood and mucous are in patient's stool. Nausea and vomiting accompany the cramping. A high fever develops with chills and dehydration.

**Shigellosis**

**Patient #7 Background**

Patient has been swimming in a local river. Upon his/her return, general weakness and discomfort occur (malaise). Patient loses appetite and develops fever, mild diarrhea, and nausea. Patient's skin and whites of his/her eyes becomes yellow. The patient is sick for a week.

**Hepatitis**

**Waterborne Disease Analysis Key**

1a. Recently visited a foreign country or associated with someone who had visited a foreign country. (Go to 2)

lb. Did not have contact with foreigners or people who had traveled to a foreign country. (Go to 3)

2a. Rose-colored spots on skin, malaise, loss of appetite, high fever, delirious, tender abdomen. (Typhoid Fever)

2b. No rose-colored spots on skin, diarrhea, tender and sore muscles, slight fever, stomach cramps, nausea, and vomiting. (Gastroenteritis)

3a. Went camping, hiking, or swimming. (Go to 4)

3b. Did not recently participate in any outdoor activities. (Go to 5)

4a. Drank water from a spring, stream, or lake. Abdominal cramps, greasy, smelly bowel movements, excessive gas, and weight loss. (Giardiasis)

4b. Did not drink water, but spent time in the water. Malaise, anorexia, fever, nausea, jaundice. (Hepatitis A)

5a. Abdominal cramps. (Go to 6)

5b. No abdominal cramps, but fever, chills, cough, and rapid breathing. (Legionnaire’s Disease)

6a. Recalls eating poorly cooked meat, malaise, fever, dysentery. (Salmonella)

6b. Blood and mucous in stool, generally a child who had contact with other children. (Shigella)